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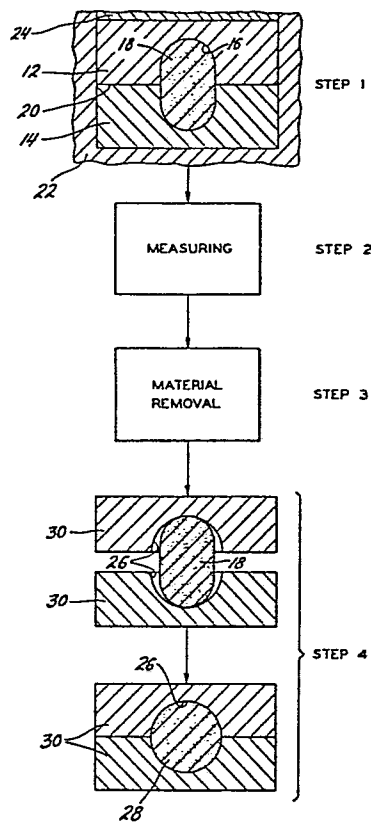
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54 Method of forming an article.

57 A method of forming an article to a final form in a final cavity between two dies by forming a preform having the general shape of the final form of the article and thereafter measuring the amount of material contained in the preform and removing any material from the preform in excess of the amount of material required to completely fill the volume of the final cavity and then enclosing the preform in the final cavity to completely surround the preform and conform the preform to the shape of the final cavity to produce the final form of the article. Preferably, the preform is first formed by compacting powder metal so as to have a greater dimension in one direction than the final form and a lesser dimension in a transverse direction. After weighing the preform and removing excess material from the exterior of the preform, the preform is placed between two dies of a press which close to initially apply pressure to the greater dimension of the preform to reduce that dimension to the final desired dimension while increasing the lesser dimension to the final desired dimension of the final preform.

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BACKGROUND OF THE INVENTION

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This invention relates to a method of forming an article to a final form in a cavity which surrounds the article to define the final desired form of the article.

5 Such forming is accomplished in forging and like processes. Although applicable to forging and like processes, the subject invention has particular utility and will be described in connection with forming an article by the hot consolidation of powder material.

10 Hot consolidation can be accomplished by filling a container with a powder to be consolidated. The container is usually evacuated prior to filling and then hermetically sealed. Heat and pressure are applied to the filled and sealed container. At elevated temperatures,
15 the container functions as a pressure-transmitting medium to subject the powder to the pressure applied to the container. Simultaneously, the heat causes the powder to fuse by sintering. In short, the combination of heat and pressure causes consolidation of the powder into a
20 substantially fully densified and fused mass in which the individual powder particles change shape as they are forced together and are united into a substantially homogeneous mass.

After consolidation, the container is removed
25 from the densified powder compact or preform and the preform is then further processed through one or more steps, such as forging, machining, grinding and/or heat treating.

Because the volume of the cavity in the



container for hot consolidation may vary from container to container, the final configuration may vary from compacted part to compacted part. Another variable is that the density of the powder may vary from one fill to the next.

5 In addition, the particle size may differ from one fill to the next. All of these factors can contribute to parts being below or above tolerances when it is, of course, desirable to consistently produce part after part with the same shape or form with the same amount of material or
10 mass in each part. Another problem which occurs is that when the part is compacted between two dies, flash may occur on the part at the parting line of the two dies. This flash, of course, must be removed in a subsequent operation.

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SUMMARY OF THE INVENTION

These problems may be overcome by the subject invention which provides a method of forming an article to a final form in a final cavity completely surrounding and having the final form of the article. The method in-
20 cludes the steps of forming a preform having the general shape of the final form of the article, measuring the amount of material contained in the preform, removing any material from the preform in excess of the amount of material required to completely fill the volume of the
25 final cavity and enclosing the preform in the final cavity to completely surround the preform and conform the preform to the shape of the cavity to produce the final form of the article.

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BRIEF DESCRIPTION OF THE DRAWING 0054404

Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description
5 when considered in connection with the accompanying drawing which is a flow diagram illustrating the major steps involved in the method of the subject invention.

DESCRIPTION OF THE INVENTION

It will be appreciated that the subject invention
10 tion may be utilized for shaping parts by forging or in any other process where a part is to be conformed to the shape of a cavity. However, the invention has particular utility and will be described in connection with the hot consolidation of various metallic powders and nonmetallic
15 powders, as well as combinations thereof, to form a densified powder article. The invention may be utilized to consolidate metallic powder into complex shapes by utilizing a "fluid die" or "thick-walled" container of the type described in United States Patent 4,142,888
20 granted March 6, 1979 in the name of Walter J. Rozmus, the disclosure of which is hereby incorporated by reference. By way of definition, a thick-walled container is of sufficient thickness so that the exterior surface of the walls do not closely follow the contour
25 or shape of the cavity. This insures that sufficient container material is provided so that, upon the application of heat and pressure, the container material will act like a fluid to apply hydrostatic pressure to the powder in the cavity. The use of a thick-walled



container produces a near-net shape having close dimensional tolerances with a minimum of distortion.

The drawing illustrates the steps of the method of forming an article to a final form in a final cavity completely surrounding and having the final form of the article. Step 1 is the forming of a preform having the general shape and mass of the final form of the article. Step 2 includes measuring the amount of material or mass of the material contained in the preform resulting from Step 1. Step 3 includes removing any material or mass from the preform in excess of the amount of material or mass required to completely fill the volume of the final cavity. Step 5 is the enclosing of the preform in the final cavity to completely surround the preform and conform the preform to the shape of the final cavity to produce the final form of the article.

Step 1 shows a thick-walled container formed by at least two mating container parts 12 and 14. The container parts 12 and 14 define a cavity 16 in which powder 18 is disposed for consolidation. As illustrated, the container parts 12 and 14 define the cavity 16 when they are mated together at the mating surfaces 20, as by welding.

The densified or compacted preform 18 may be of various complex shapes. As illustrated in Step 1, there is shown a cross section through the container and the compacted preform illustrating a cross section of the preform which is elongated or oval. The final shape or form of the article, by way of illustration, will be

circular as illustrated in Step 5. Although it will be appreciated that various shapes may be produced in accordance with the subject invention and that the shapes along the longitudinal axis of a given part may change
5 significantly.

In Step 1 a quantity of powder 18 is encapsulated in a cavity 16 in a thick walled container defined by the parts 12 and 14 with the container having walls entirely surrounding the cavity 16 and of sufficient
10 thickness so as not to closely follow the contour of the cavity 16 and of a material which is substantially fully dense and incompressible and capable of plastic flow at elevated temperatures. The container defined by the parts 12 and 14 is generally rectangular in cross section and
15 does not follow the contour of the cavity 16 as there are different thicknesses of the container about the cavity 16.

The container parts 12 and 14 and the powder are heated to a temperature at which the powder 18 will
20 densify. External pressure is applied to the entire exterior surface of the container parts 12 and 14 thereby causing plastic flow of the container parts 12 and 14 to subject the powder to hydrostatic pressure which causes the powder to densify into a preform. The pressure
25 is applied to the container parts 12 and 14 by placing the container parts within a constraining cavity in a press die 22 and applying downward pressure to the container parts 12 and 14 by a ram 24 of a press. This is accomplished in accordance with the teachings of the

aforementioned United States Patent 4,142,888.

The preform 18 is then removed from the container parts 12 and 14. This may be accomplished by various means such as etching, pickling, machining, etc.

5 One very satisfactory method of removing the preform 18 from the container parts 12 and 14 is by melting the container material from about the preform 18. The container parts 12 and 14 may be formed from a material which melts at a combination of temperature and time at that temperature
10 which combination would not undesirably or adversely affect the properties of the powder preform 18, i.e., after having been consolidated to define the densified powder compacted preform 18. For example, the container may be made from a metal such as copper. This may be
15 accomplished in accordance with the teachings of United States Patent Application Serial No. 173,648 filed July 30, 1980 in the name of J. R. Lizenby and assigned to the assignee of the subject invention.

After compaction of the preform 18 and the
20 removal of the preform 18 from the container parts 12 and 14, the amount of material or mass contained in the preform is measured. This may be accomplished by weighing the preform in Step 2. Thereafter, the method includes the step of removing any material about the exterior of
25 the preform 18 which is in excess of the amount of material in the final desired form of the article. The material may be removed in Step 3 by passing the preform 18 through an etching bath. The preform would be submerged in a solution in an etching bath under

predetermined conditions to remove the proper amount of material or mass from the preform. The predetermined conditions would include the temperature of the solution, the electrical current passing through the solution and the time the preform is submerged within the solution.

Step 4 illustrates the enclosing of the preform 18 in the final cavity 26 to completely surround the preform 18 and conform the preform 18 to the shape of the final cavity 26 to produce the final form of the article 28. The preform 18 is enclosed in the final cavity 26 by placing the heated preform between dies 30 of a press. The dies 30 define the final cavity 26 and the closing of the dies 30 apply pressure to the preform 18 to form it into the final form of the article 28. The dies 30 may be placed in a variety of well-known presses.

As the drawing illustrates, the preform 18 is formed so as to have a greater dimension in a first direction therethrough (vertical as shown) than the final desired dimension in the first (vertical) direction through the final form 28. The preform 18 is also formed to have a lesser dimension in a second direction (horizontal) transverse to the first direction than the final desired dimension in the second direction (horizontal) through the final form 28. As illustrated, the cross-sectional configuration of the preform 18 is oblong or oval whereas the cross-sectional configuration of the final form is circular.

The preform 18 is enclosed in the dies 30 by closing the dies 30 to initially apply pressure to the

preform 18 in the first direction which is vertical as illustrated. In other words, the dies 30 first contact the ends of the oblong shape to initially apply pressure to the preform 18 in the first or vertical direction to

5 decrease the dimension in the first or vertical direction to the final desired dimension of the article 28. As this occurs, there is also an increase in the dimension in the second or horizontal direction of the preform 18 to the final desired dimension of the article 28. In other

10 words, as the dies 30 move together, they initially engage the preform at the intentionally oversize dimension in the direction of the closing of the dies and, since the other transverse dimension between the sides is smaller than required, that dimension grows or increases. Since

15 the preform 18 has been measured and any mass or material in excess of that required to precisely fill the cavity 26 has been removed, the sides of the preform 18, when increasing in dimension horizontally, contact the walls of the cavity 26 at the same time the dies 30 engage one

20 another at the parting line therebetween. As will be appreciated, in this manner there is no resulting flash in the final article 28, i.e., there is no material of the article 28 squeezed outwardly between the dies 30 between the parting faces thereof and outside the cavity

25 26. Accordingly, not only is there a precise article in terms of shape resulting from the method but the wear of the dies 30 at the parting faces therebetween adjacent the cavity 26 should be eliminated.

In many instances it will be desirable to



initially form the preform 18 with a greater amount of material or mass than the amount of material in the final form of the article 28. This will prevent forming preforms 18 which are unusable because of less material or mass than desired in the final article 28.

It will be appreciated that the final cavity 26 is final only in that it provides the final shape of the desired article but the term does not mean that the article 28 may not be processed further to undergo further processing. It should also be appreciated that in the removal step, particularly when processing articles of complex shapes, different portions of the articles may have proportionally different amounts of material removed therefrom than other portions of the article. The importance being to remove material from the preform 18 so that the different portions of the preform are in proportion to the final cavity 26 and that the total volume in terms of material or mass of the preform is precisely the same as the volume of the final cavity 26.

It should also be appreciated that the preform may also be formed in an autoclave instead of a press.

The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims wherein reference

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numerals are merely for convenience and are not to be
in any way limiting, the invention may be practiced
otherwise than as specifically described.

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1. A method of forming an article to a final form in a final cavity completely surrounding and having the final form of the article including the steps of: forming a preform having the general shape of the final
5 form of the article and enclosing the preform in the final cavity to completely surround the preform and conform the preform to the shape of the final cavity to produce the final form of the article, said method characterized by measuring the amount of material con-
10 tained in the preform and removing any material from the preform in excess of the amount of material required to completely fill the volume of the final cavity before enclosing the preform in the final cavity.

2. A method as set forth in claim 1 further characterized as forming the preform to have a greater dimension in a first direction therethrough than the final desired dimension in the first direction through
5 the final form and a lesser dimension in a second direction transverse to the first direction than the final desired dimension in the second direction through the final form and enclosing the preform by initially applying pressure to the preform in the first direction to
10 decrease the dimension in the first direction to the final desired dimension while increasing the dimension in the second direction to the final desired dimension.

3. A method as set forth in claim 2 further



characterized as enclosing the preform in the final
cavity by placing the preform between dies in a press
which define the final cavity and closing the dies to
5 initially apply pressure to the preform in the first
direction.

4. A method as set forth in claim 3 further
characterized as forming the preform with a greater
amount of material than the amount of material in the
final form of the article.

5. A method as set forth in claim 4 further
characterized as removing the excess material by placing
the preform in an etching bath under predetermined
conditions.

6. A method as set forth in claim 5 further
characterized as measuring the amount of material in
the preform by weighing the preform.

7. A method as set forth in claim 1 further
characterized as forming the preform with a greater
amount of material than the amount of material in the
final form of the article.

8. A method as set forth in claim 1 further
characterized as forming the preform by; encapsulating
a quantity of powder in a first cavity in a thick walled
container having walls entirely surrounding the first
5 cavity and of sufficient thickness so as not to closely
follow the contour of the first cavity and of a material
which is substantially fully dense and incompressible and
capable of plastic flow at elevated temperatures, heating
the container and powder to a temperature at which the

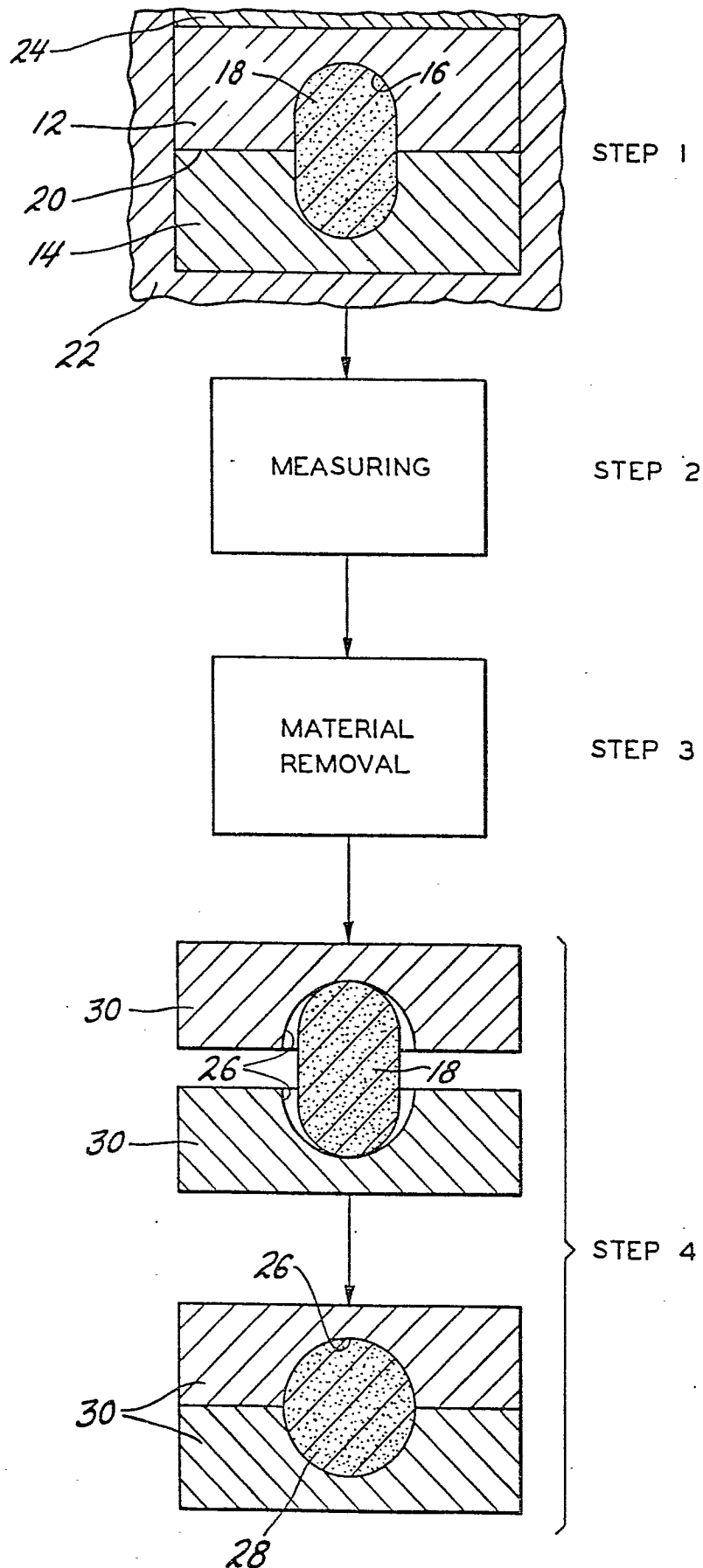


10 powder will densify, and applying external pressure to the entire exterior surface of the container thereby causing plastic flow of the container walls to subject the powder to hydrostatic pressure which causes the powder to densify into the preform.

9. A method as set forth in claim 8 further characterized as removing the preform from the container by melting the container material from about the preform.

10. A method as set forth in claim 8 further characterized as forming the preform by encapsulating the powder in the first cavity having a greater dimension in a first direction than the final desired dimension in the first direction of the final form and a lesser dimension in a second direction transverse to the first direction than the final desired dimension in the second direction of the final form and enclosing the preform in the final cavity and applying pressure to the preform initially in the first direction to decrease the dimension in the first direction to the final desired dimension while increasing the dimension in the second direction to the final desired dimension.







European Patent
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EUROPEAN SEARCH REPORT

0054404

Application number

EP 81 30 5803

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	GB - A - 1 495 705 (R.J. DAIN et al.) * Claims 1,12 *	1,4,7	B 22 F 3/02 3/12 B 30 B 11/00
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A	US - A - 3 866 303 (S.E. CHEHI) * Claims 1,2; column 3, lines 17-21; figures 1,4 *	2-3, 8,10	
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A	FR - A - 2 015 955 (SINTERMETALLWERK KREBSOGE) * Claim 1; page 3, lines 6-15 * & US - A - 3 785 038	2-3, 8,10	TECHNICAL FIELDS SEARCHED (Int.Cl. 3) B 22 F B 30 B
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A	FR - A - 2 399 394 (THOMSON-CSF)		
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A	DE - A - 2 724 524 (KELSEY - HAYES)		
D	& US - A - 4 142 888		

			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons
			& member of the same patent family, corresponding document
☒ The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 26-03-1982	Examiner SCHRUERS